

TRUXTUN PARK STRAY VOLTAGE STUDY

Engineering Design Technologies, Inc.

! Warning: this presentation contains references to drowning !

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ENGINEERING DESIGN TECHNOLOGIES (EDT)

EDT is a multidisciplinary engineering firm with over a decade experience of investigating stray currents with an office in Glen Burnie, MD.



SUMMARY

No hazardous* amounts of stray voltages were detected during this study.

Swimming near docks with electrical service is never recommended according to the National Electric Code (NEC).

During the systematic shutdown and startup of the power to the Harbormaster's dock, there were no recorded voltage changes in the water, concurrent with the operation of the circuit breakers, or as a result of the fluctuations in the grounding system's currents.

* One 2 second event was captured during a six-day period of recording.



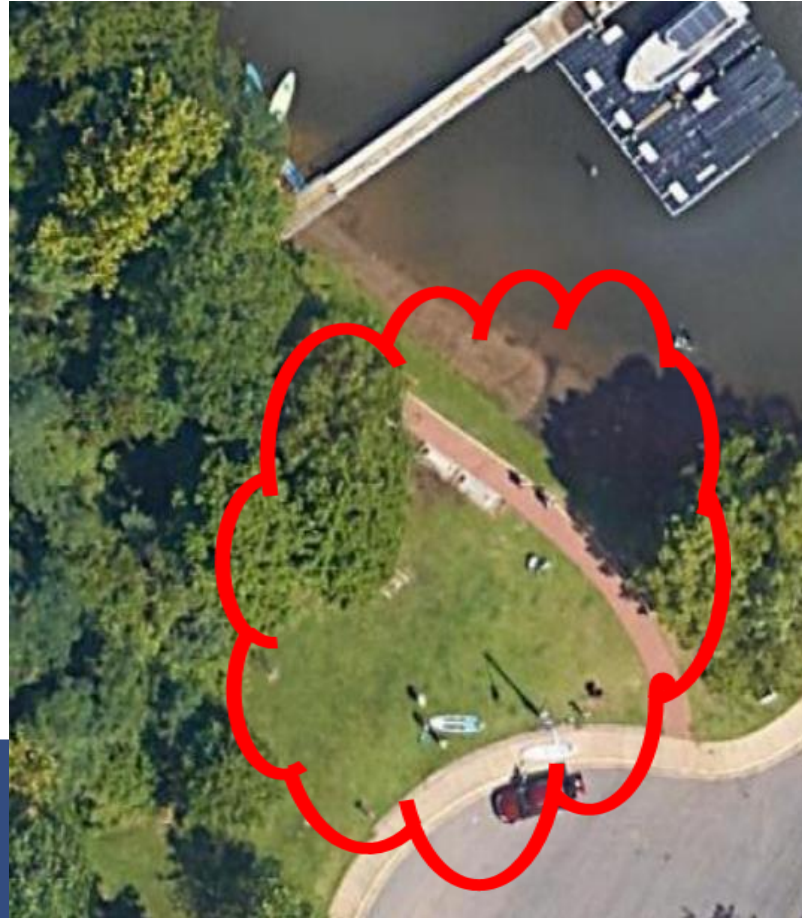
INTRODUCTION



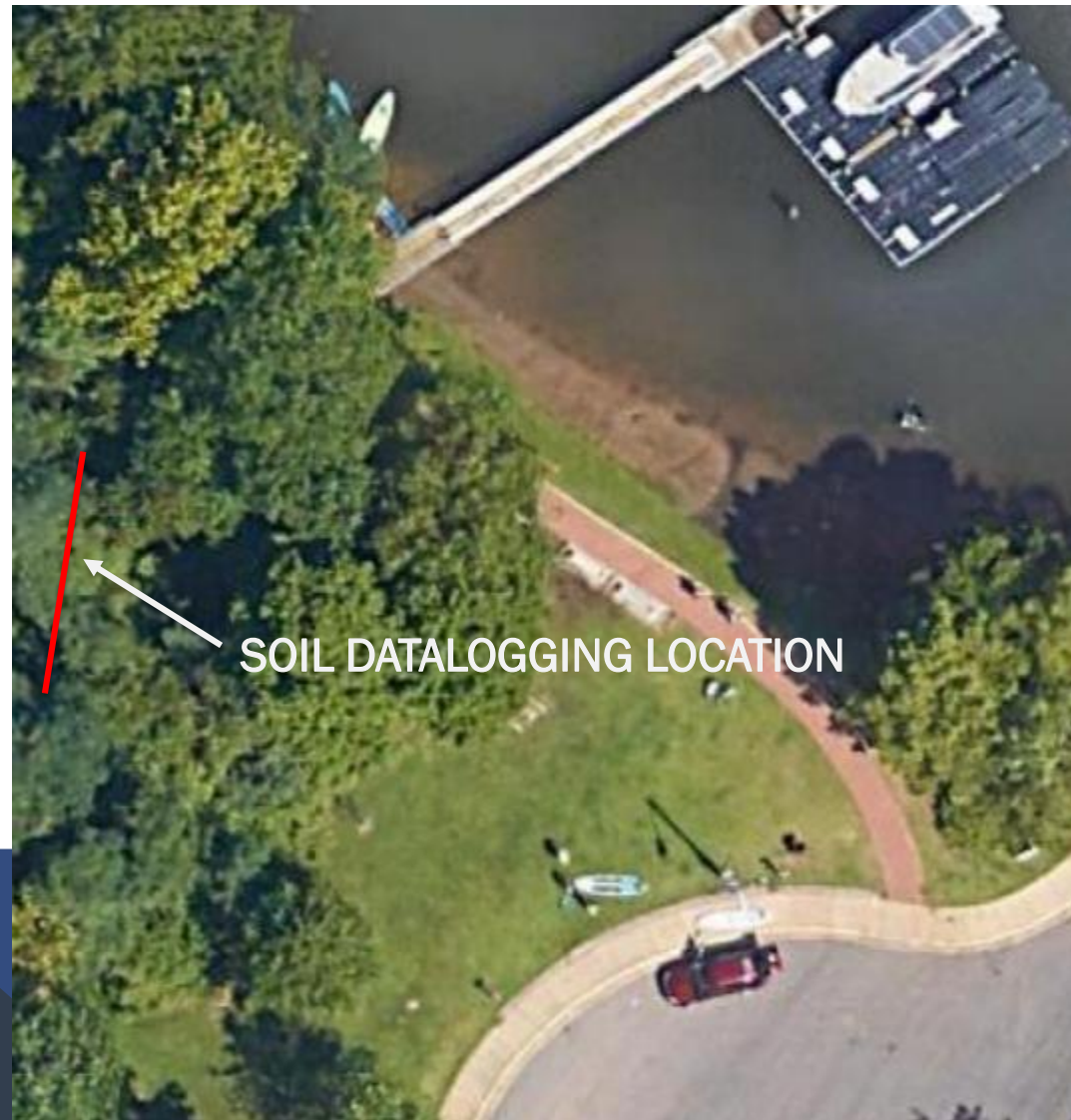
TEST LOCATIONS- “RICKETY” FOOT BRIDGE AND MAIN DOCK



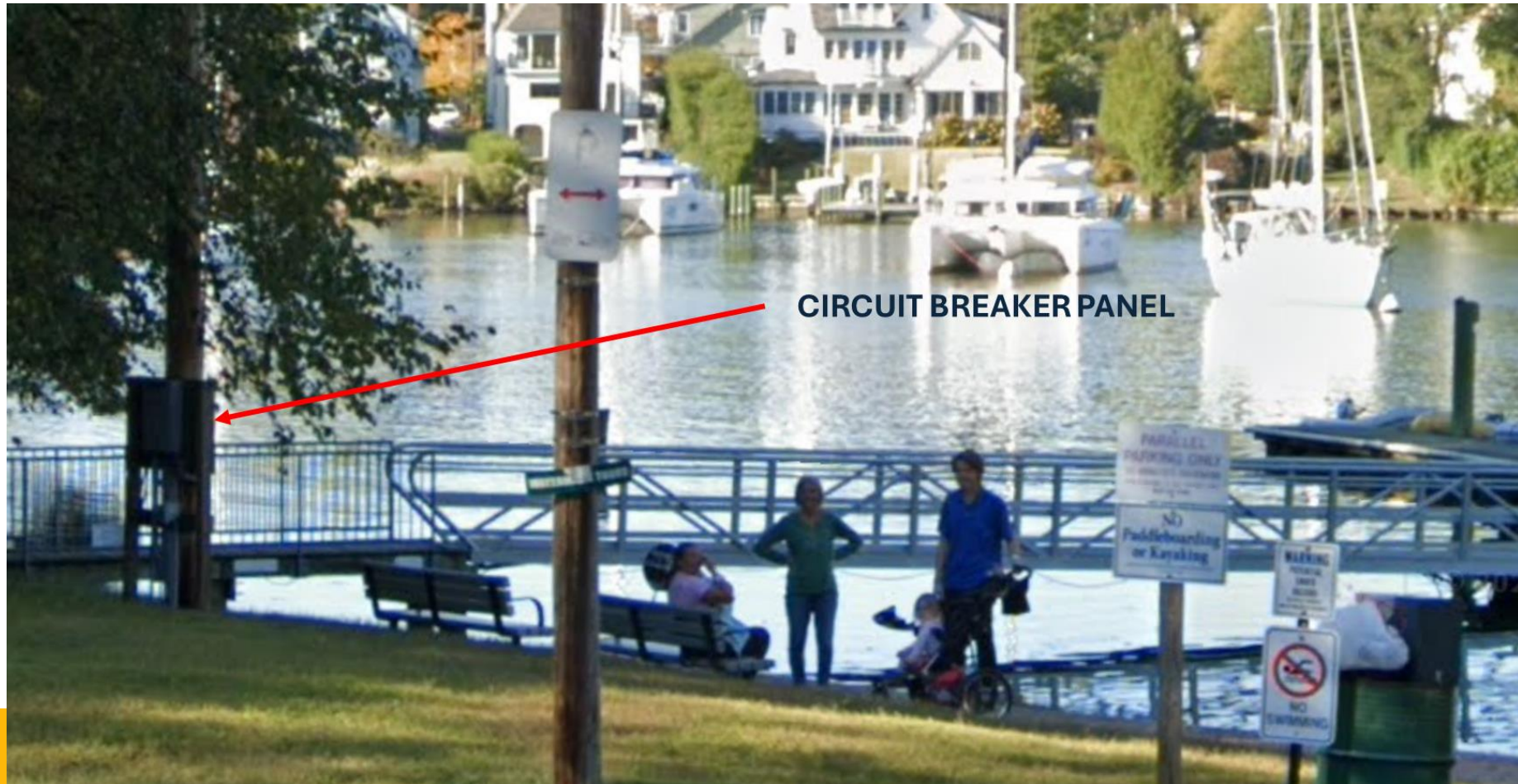
**INSTANTANEOUS TESTING ON LAND WAS PERFORMED ON THE SOIL
AND BEACH IN THIS GENERAL AREA.**



DATALOGGING ON LAND



CURRENT MEASUREMENTS WERE TAKEN ON GROUNDING



BACKGROUND INFORMATION

- There have been reports of electric tingling sensations that were experienced in the water near the boat ramps at Truxtun Park.
- ESD (Electrical Shock Drowning) is a serious public health concern.

STRAY VOLTAGES CAN ORIGINATE FROM MANY SOURCES:

- Shipboard power
- Shore power to vessels
- Electrical power distribution systems and pumps etc.
- Corrosion control systems
- Solar activity (flares or coronal mass ejections)

NOTE: Conditions causing stray voltages can change at any time.



TINGLING SENSATIONS

The reported tingling sensations can be indicative of alternating currents in the water.

Research by others has shown that direct currents are not normally detected by humans except when they are started and stopped. Alternating currents effectively start and stop repeatedly, and as a result are much more easily felt.

Research has shown that currents as low as one one-thousandth of an ampere (milliampere or mA) can be perceptible. Since all measurements in this study are reported in terms of thousandths of a volt (mV), we must consider the resistance of the human body to the flow of electricity to find the voltage corresponding to mA. Scientists often use a conservative value of 300 ohms for the electrical resistance of a human in water. Therefore, a stray voltage of 300 thousandths of a volt (millivolts or mV) will be perceptible.

ELECTRIC SHOCK DROWNING (ESD)

For many years drownings of otherwise healthy and capable swimmers and rescuers were reported around docks and boats. Eventually investigations revealed the presence of electrical currents in the waters where the drownings occurred.

Further investigations revealed that the electrical currents did not always cause electrocutions but can cause paralysis of swimmer's muscles making swimming difficult to impossible resulting in drowning, and as the amount of current increases, the current can prevent breathing, cause ventricular fibrillation (V-FIB), and finally tissue damage.





METHODS

METHODS

Voltages were measured using two types of meters

- Data logging measurements once a second for days in fixed locations and while boating
- Instantaneous measurements using digital multimeters

All measurements were recorded while using calibrated, industry standard portable reference electrodes in contact with the soil or water.

Both types of meters provide RMS AC readings.

A decorative graphic at the bottom of the slide consisting of three overlapping geometric shapes: a yellow triangle on the left, a dark blue triangle in the center, and a medium blue triangle on the right.

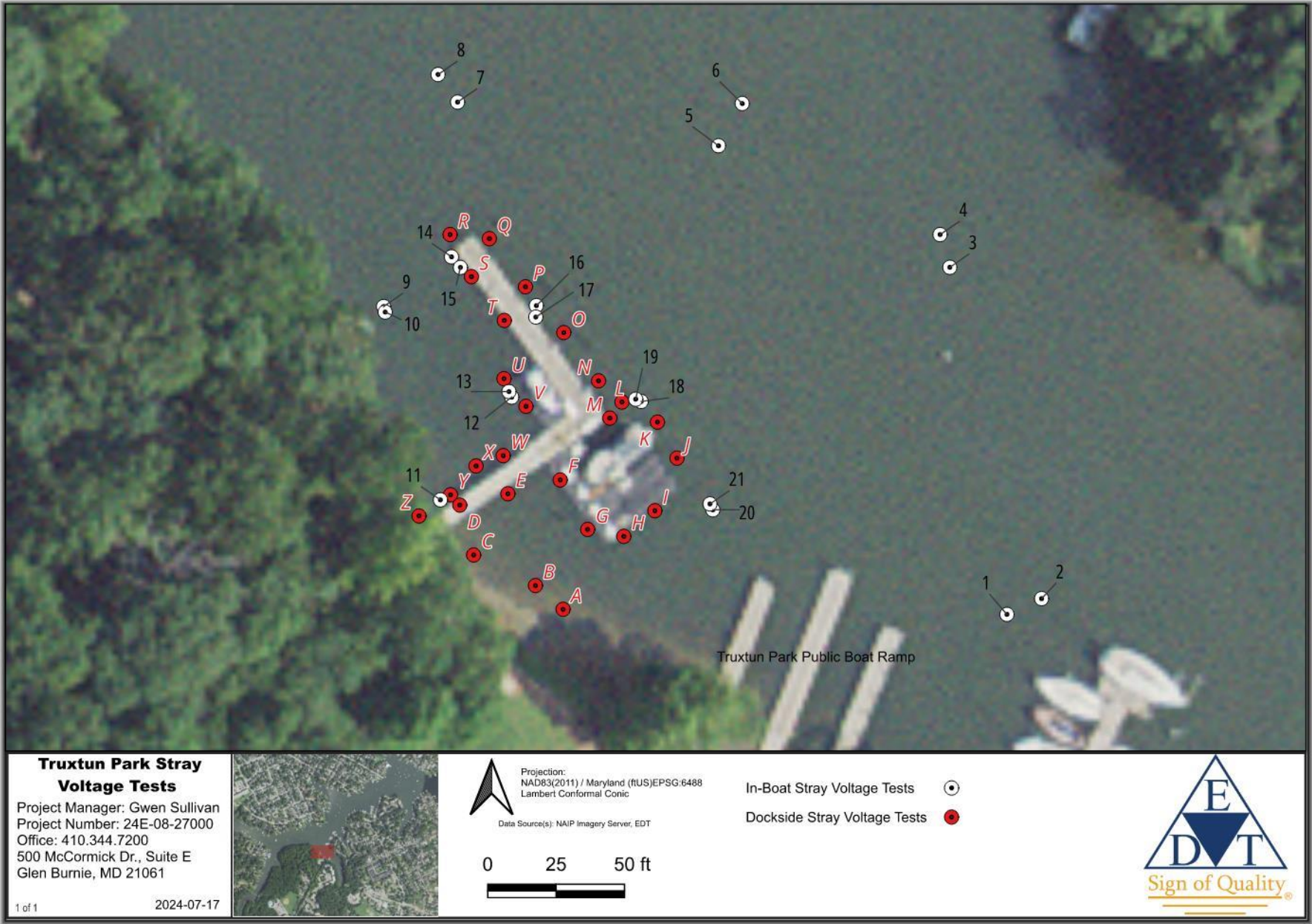
METHODS

- Data logging measurements once a second for days
 - There were three locations where these tests were conducted
 - On land: to the south of the dock
 - In water: Adjacent to the dock (to determine if findings on the land were also visible in the water)
 - In water: Adjacent to the "Rickety" bridge
- Instantaneous
 - There are two locations tested
 - Between the grounding system for the dock's circuit breaker box and an earth probe
 - Electrical current flowing on the dock's circuit breaker panel grounds

MAPS OF THE TEST LOCATIONS FIXED LOGGING IN WATER



MAPS OF THE TEST LOCATIONS INSTANTANEOUS IN WATER (ALSO LOGGED)



RESULTS

RESULTS

Stray voltages which were recorded were below the sensible threshold (except for seven seconds at the “Rickety” foot bridge) on both water and on land.

Stray voltages which were observed on land and grounding currents were not indicative of electrical leakage from the Harbor Master’s dock's power system.

The anomalous electrical currents which were observed on the grounding system for the circuit breaker panel near the dock were present when all power to the dock's circuit breaker was turned off.



RESULTS

Test	AC Max (mV)	AC Min (mV)	DC Maxv (mV)	DC Min (mV)	Comments
Long Term Testing in Water					
Location #1	24.1	2.9	14.9	0	
Location #2	3.2	0	5.8	0	
Location #3 (Vertical Test)	0	0	8.4	1.3	
Location #4 (Rickety Foot Bridge)	752.6	6.8	63.8	-87	Peak happened during thunderstorm
Short Term Testing in Water					
AC and DC in boat across inlet	50	0	5	-5	
AC and DC in boat around dock	85	0	5	-7	
Long Term Testing on Land					
5-Day Stray Voltage Test	115	16	35	-11	Patterns indicate human activity
Instantaneous measurements					
Short Term Testing on Land	790	50.1			Measured 179 Hz
Grounding System Measurements	4.6	3.237			

Current	Equivalent Voltage (Based on 300 ohms of Body Resistance) [†]	Effect on the Body
1 mA	(300 mV)	Barely perceptible
16 mA	(4,800 mV)	Maximum current an average man can grasp and “let go”
20 mA	(6,000 mV)	Paralysis of respiratory muscles
100 mA	(30,000 mV)	Ventricular fibrillation threshold



ANALYSIS

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No observed change in voltages recorded in the water during the manipulation of the breaker panel indicating the Harbormaster's dock is not associated with the voltages observed.

Over the course of ten days of datalogging and observation of instantaneous measurements NO significant voltages were detected in the water except for spikes for a few seconds.

Measurements on land revealed stray voltages which appear to be associated with human controlled electrical equipment. The voltages do not appear to present any hazards to people.

There was no correlation observed between the anomalous current measurements on the electric grounding system and the voltages in the water.



CONCLUSION

CONCLUSION

- No hazardous* amounts of stray voltages were detected during this study.
- The anomalous electrical ground-system currents do not originate from the Harbormaster dock's power system.
- Sources of hazardous voltages and currents can appear at any time due to many reasons.

* One 2 second event was captured during a six-day period of recording.



RECOMMENDATIONS

RECOMMENDATIONS

- Continue to post signage warning of possible dangerous voltages in accordance with, or more conservative than, the National Electric Code.
 - Respond immediately to any reports of electrical sensations by shutting off all electrical power and, evacuating swimmers from the water.
 - Maintain all electrical equipment associated with the facility in compliance with the National Electric Code.
 - Continue to investigate the possible sources of the tingling sensations by interviewing the swimmers who reported them.
- 
- A decorative graphic at the bottom of the slide consisting of three overlapping geometric shapes: a yellow triangle on the left, a dark blue triangle in the middle, and a medium blue triangle on the right.



QUESTIONS?

ADDITIONAL INFORMATION

TABLE 1: ESTIMATED EFFECTS OF 60 HZ AC CURRENTS*

Current	Equivalent Voltage (Based on 300 ohms of Body Resistance) [†]	Effect on the Body
1 mA	(300 mV)	Barely perceptible
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*Conduction of Electrical Current to and Through the Human Body: A Review by: Raymond M. Fish, PhD, MD, FACEP and Leslie A. Geddes, MS, PhD, DSc. The full document can be found online at: [Conduction of Electrical Current to and Through the Human Body: A Review - PMC \(nih.gov\)](#).

[†] Column by EDT

PATTERN OF PEAKS IN SOIL

THURSDAY March 21st ~ 2 HOURS IN THE MORNING

FRIDAY MARCH 22ND ALMOST EXACTLY 20 MINUTES IN THE MORNING

SATURDAY MARCH 23RD A FEW SECONDS IN THE MORNING

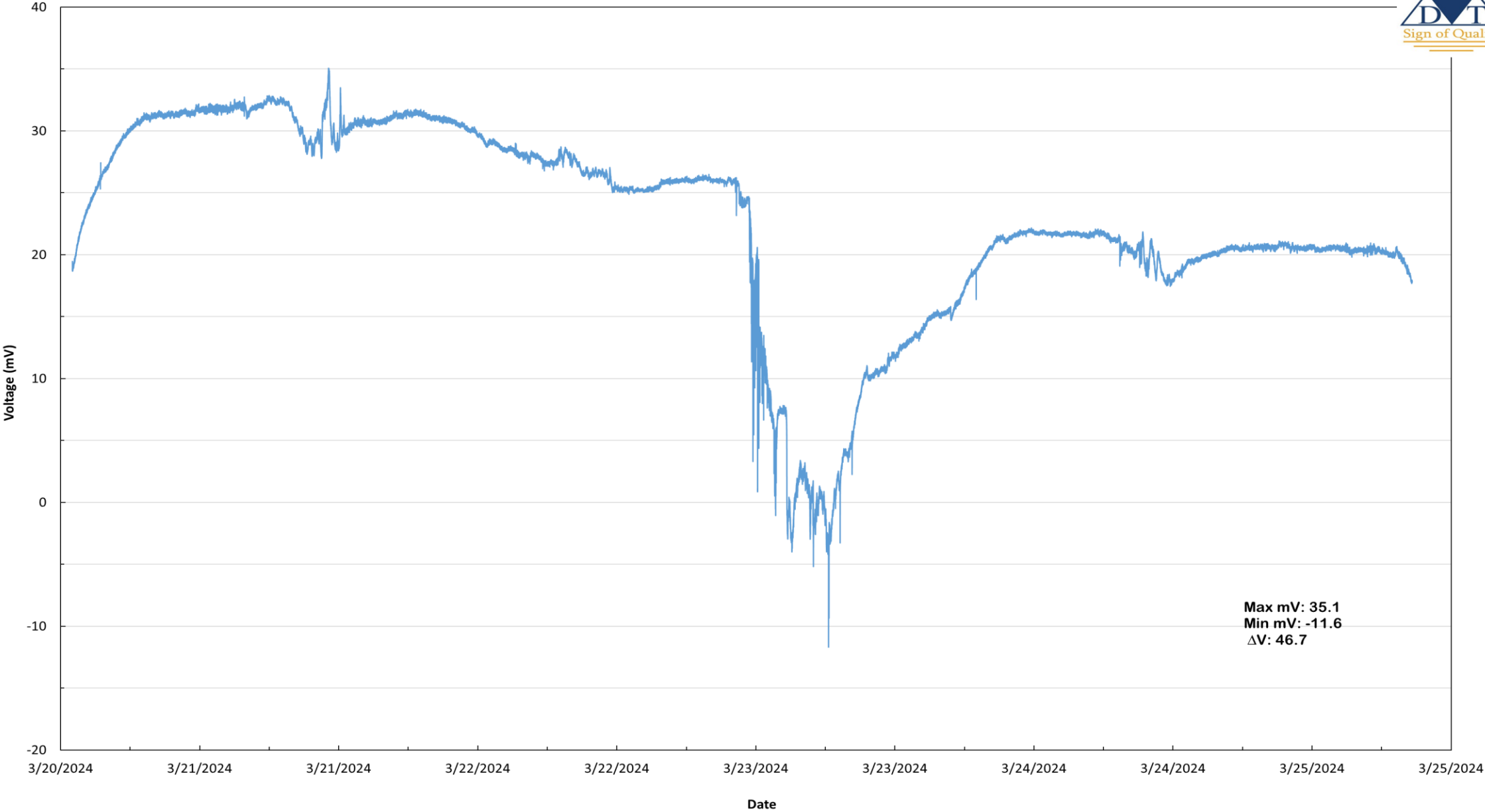
SUNDAY MARCH 24TH ~2 HOURS IN THE MORNING

MONDAY MARCH 25TH NO PEAKS RECORDED DURING THE DAY



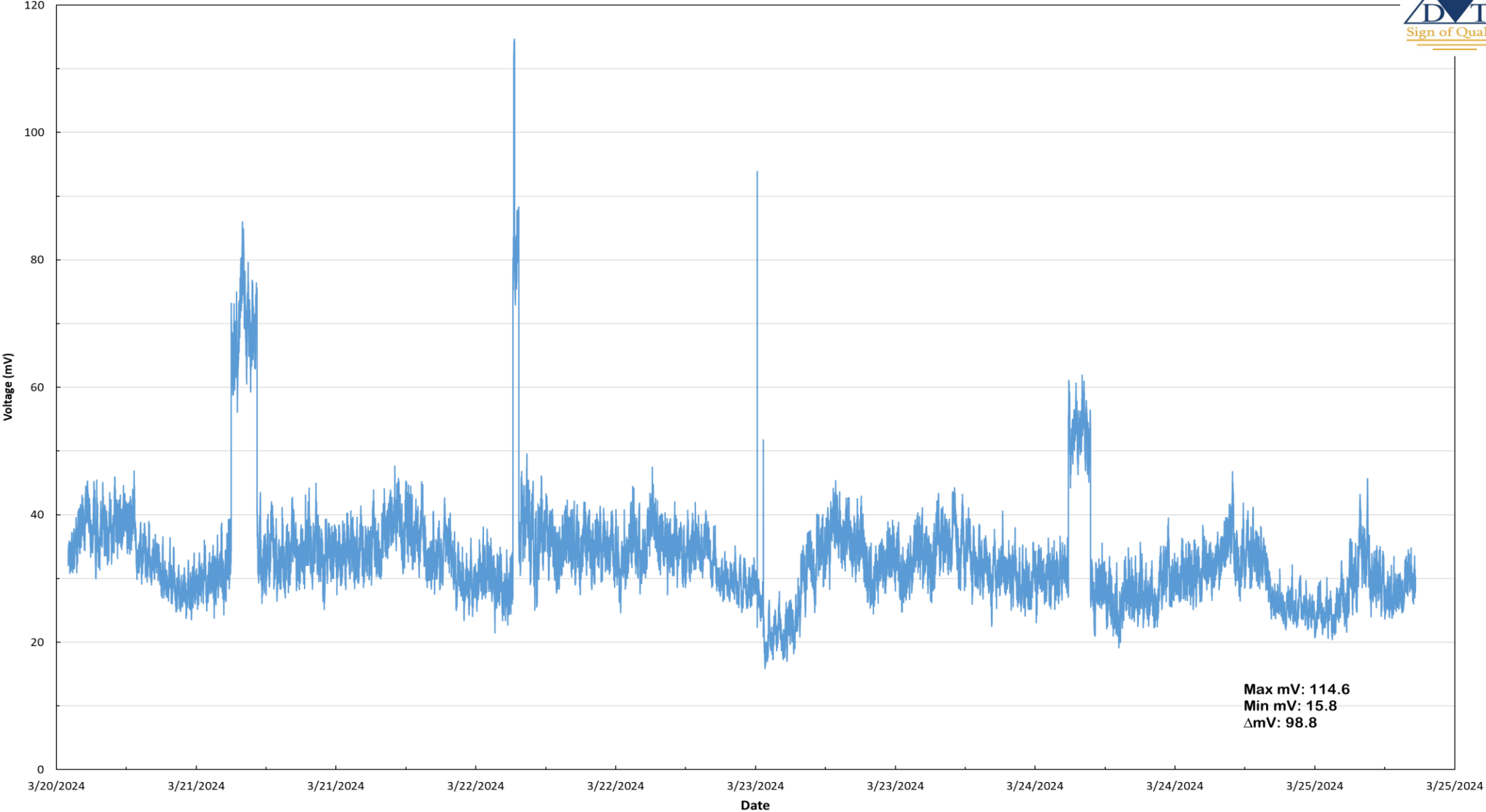
Long-term Test on Land

DC-Stray Current Testing ID Location: Annapolis Truxton Park_3/20/24 to 3/25/24

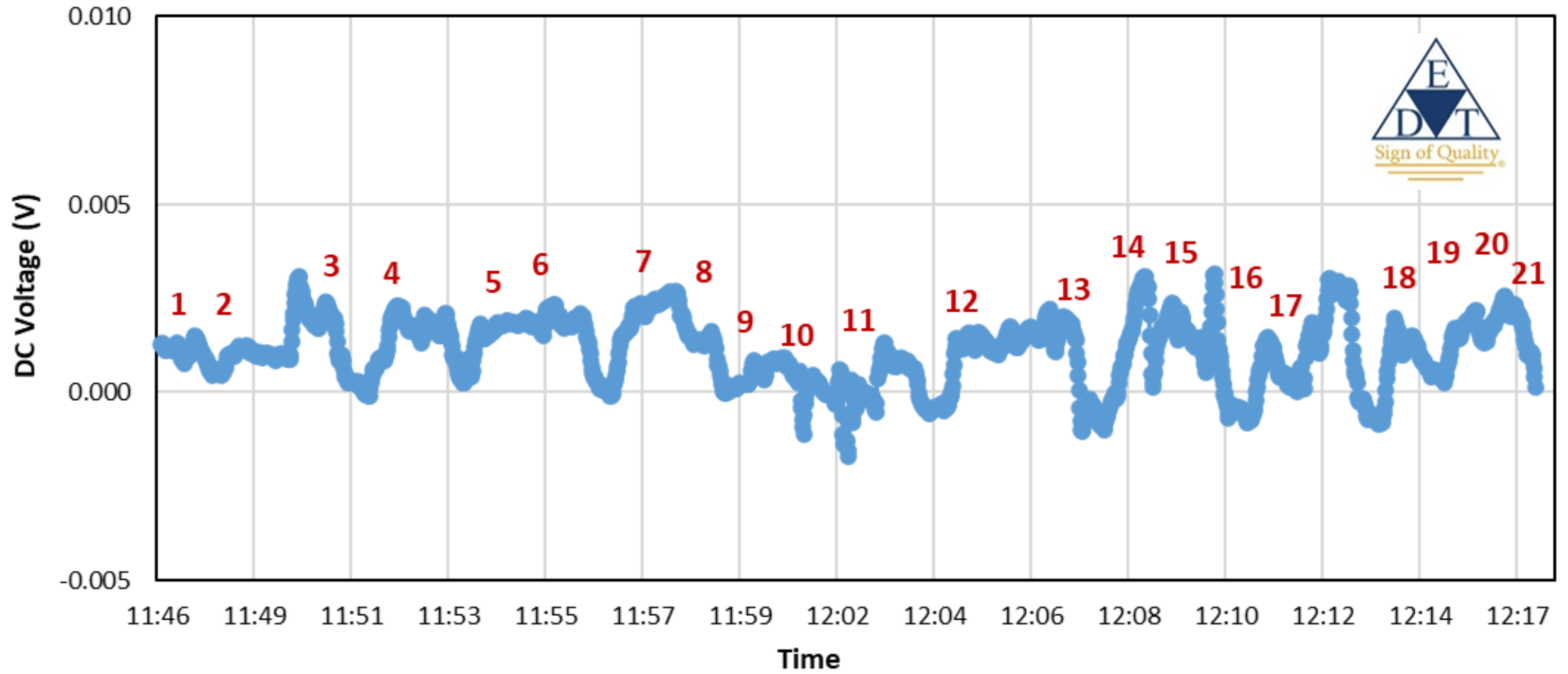


Long-term Test on Land

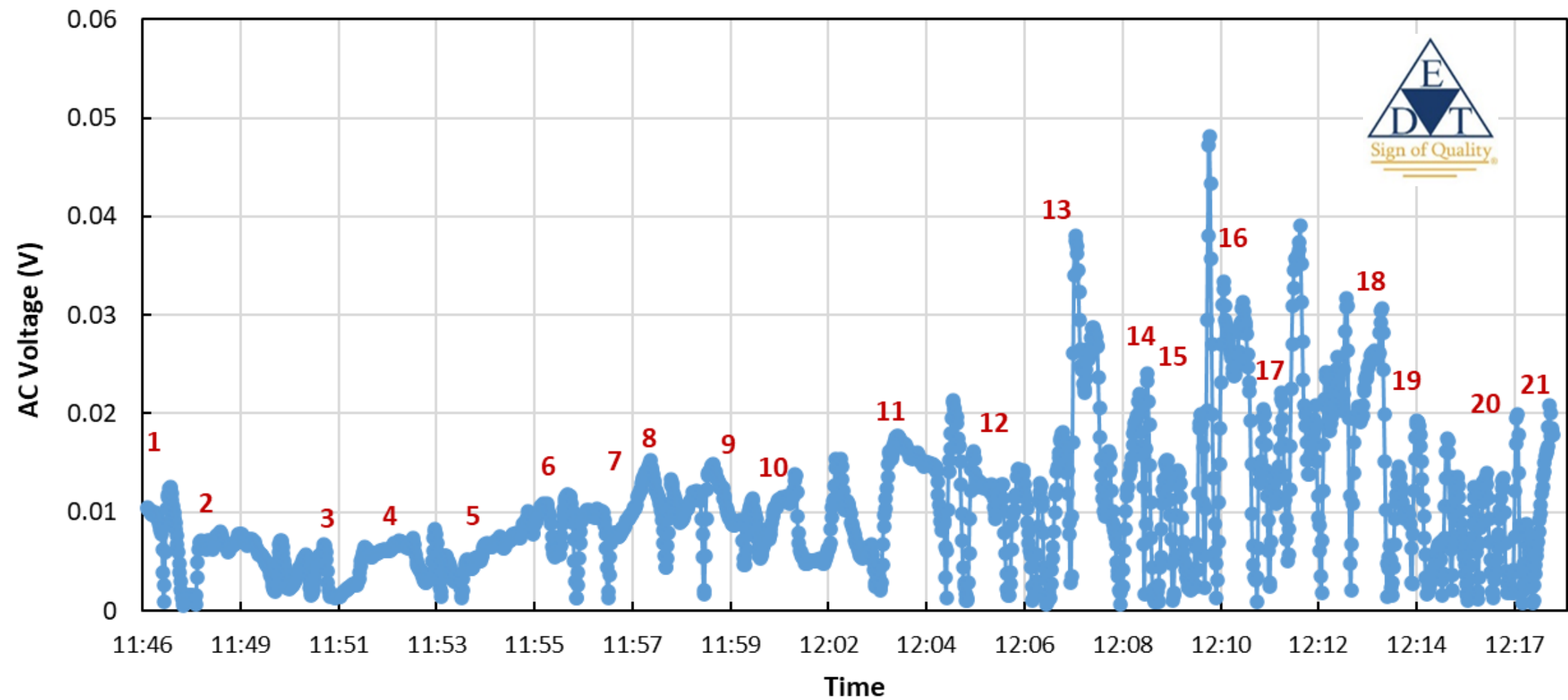
AC-Stray Current Testing ID Location: Annapolis Truxton Park_3/20/24 to 3/25/24



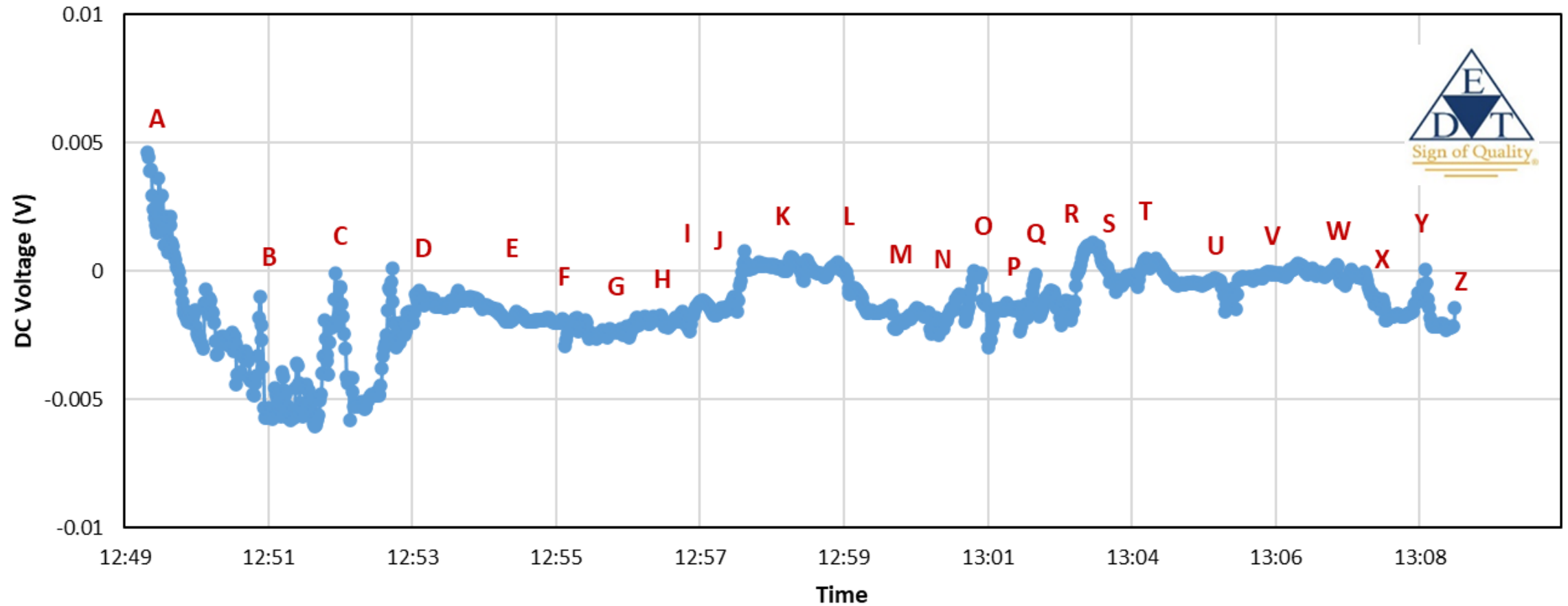
DC Voltage Readings in Water at Remote Locations Around the Inlet



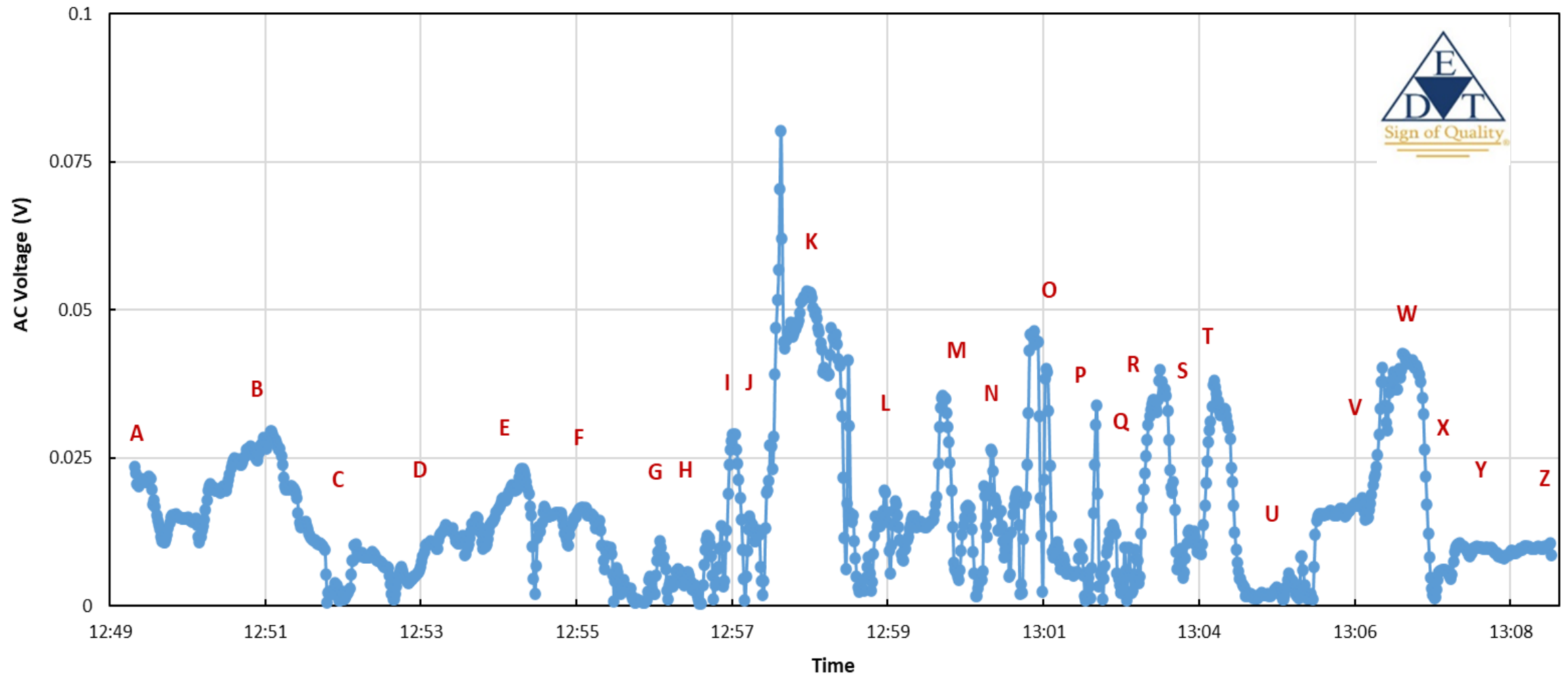
AC Voltage Readings in Water at Remote Locations Around the Inlet



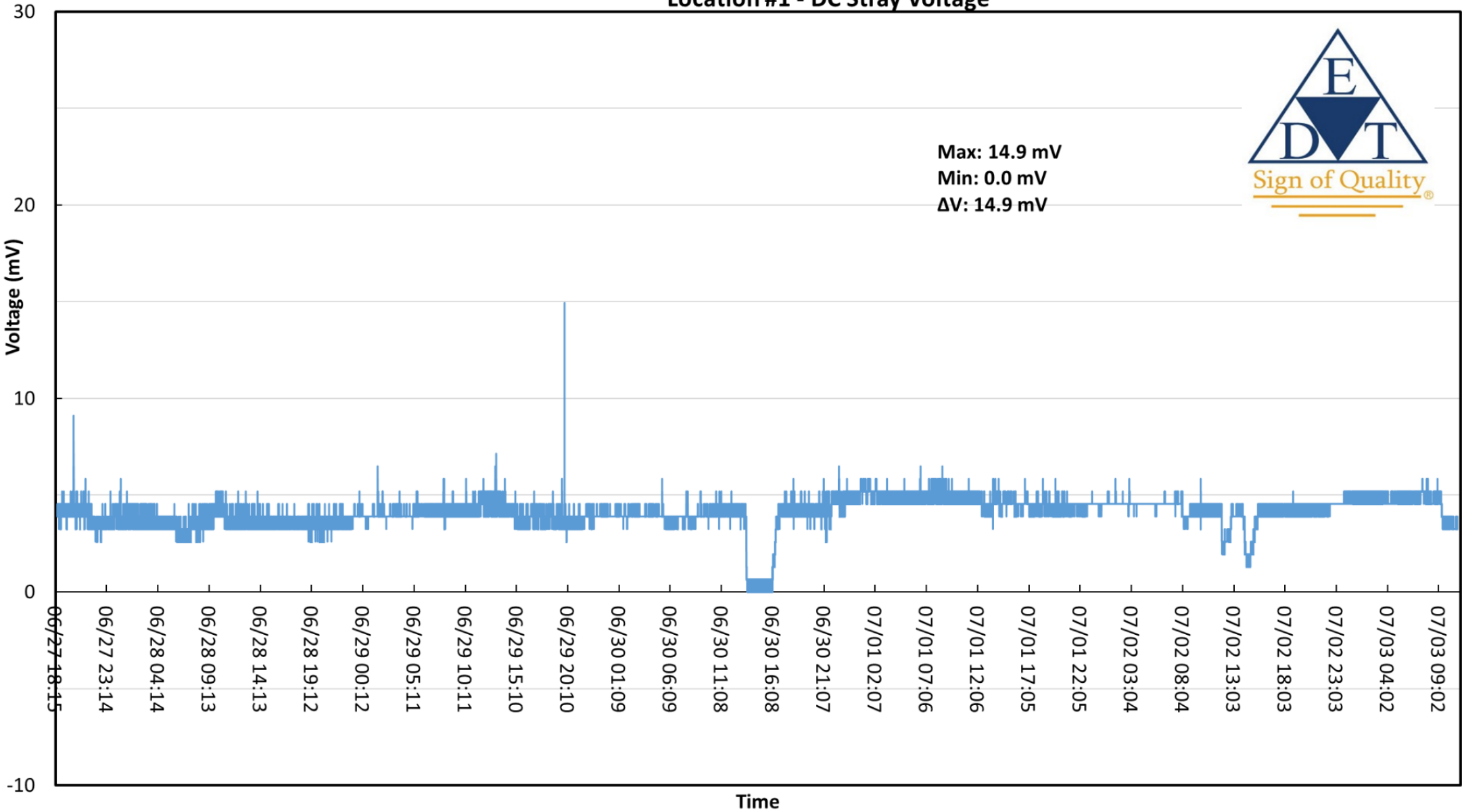
DC Voltage Readings in Water Around the Dock



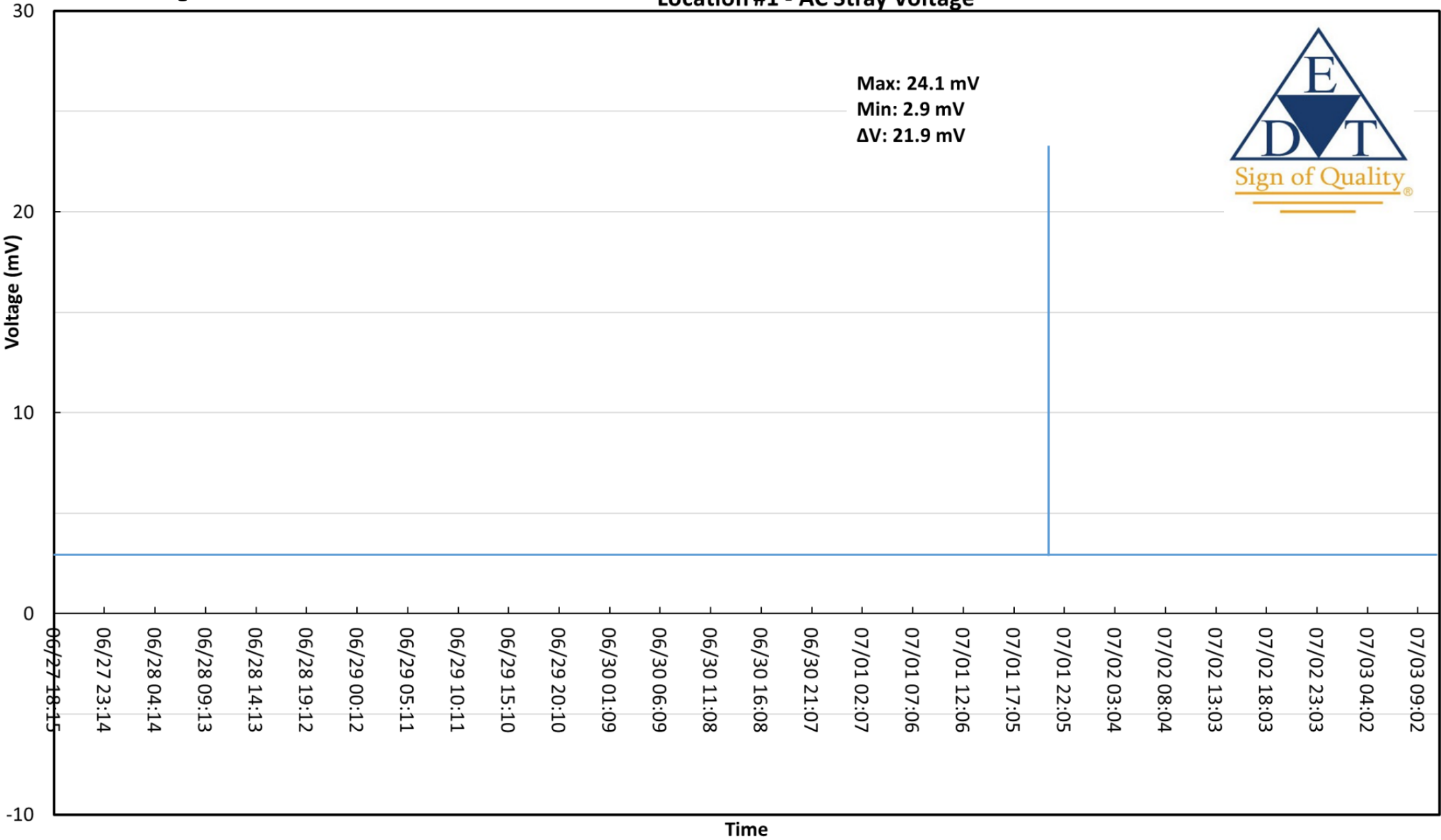
AC Voltage Readings in Water Around the Dock

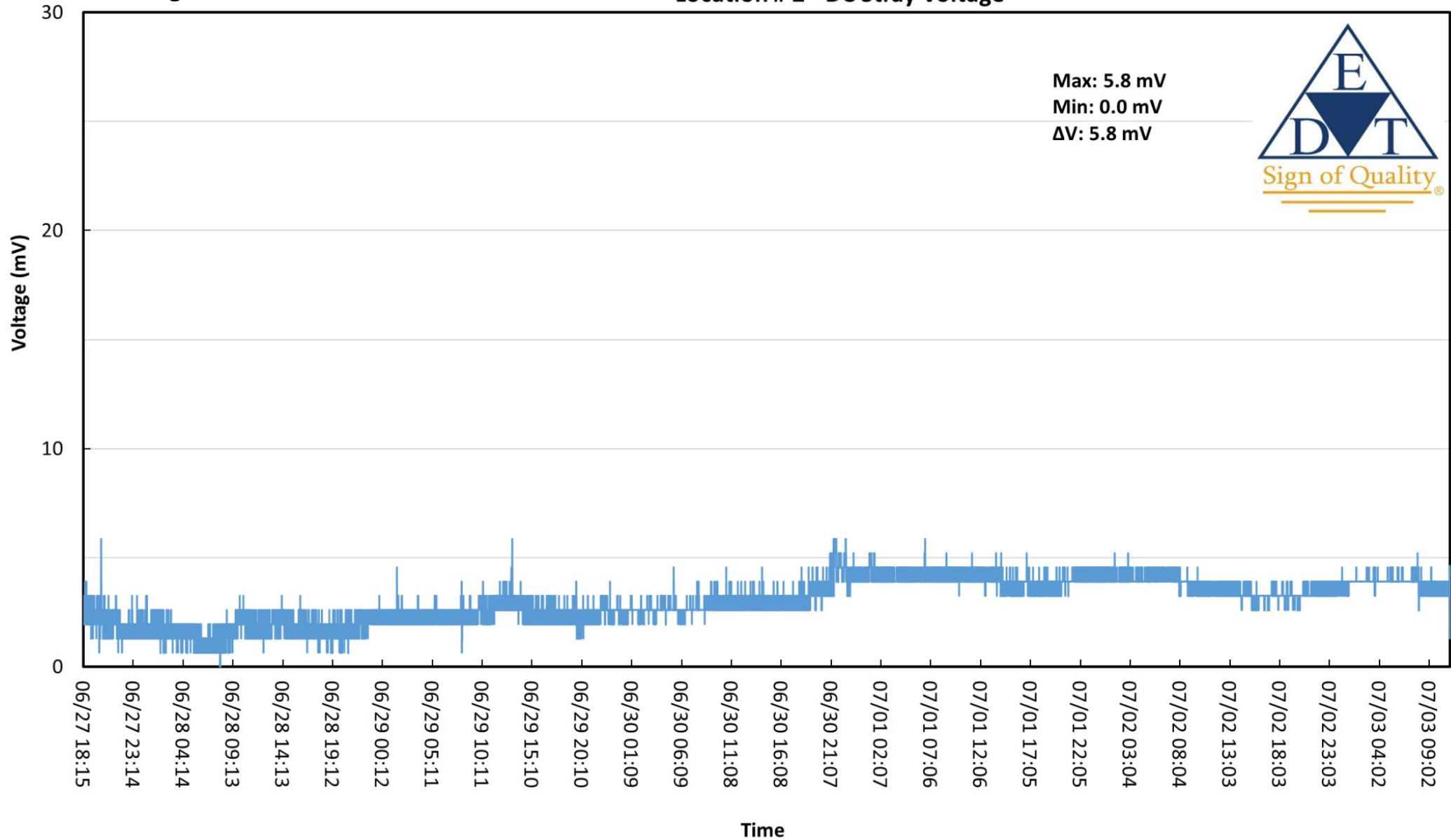


Location #1 - DC Stray Voltage



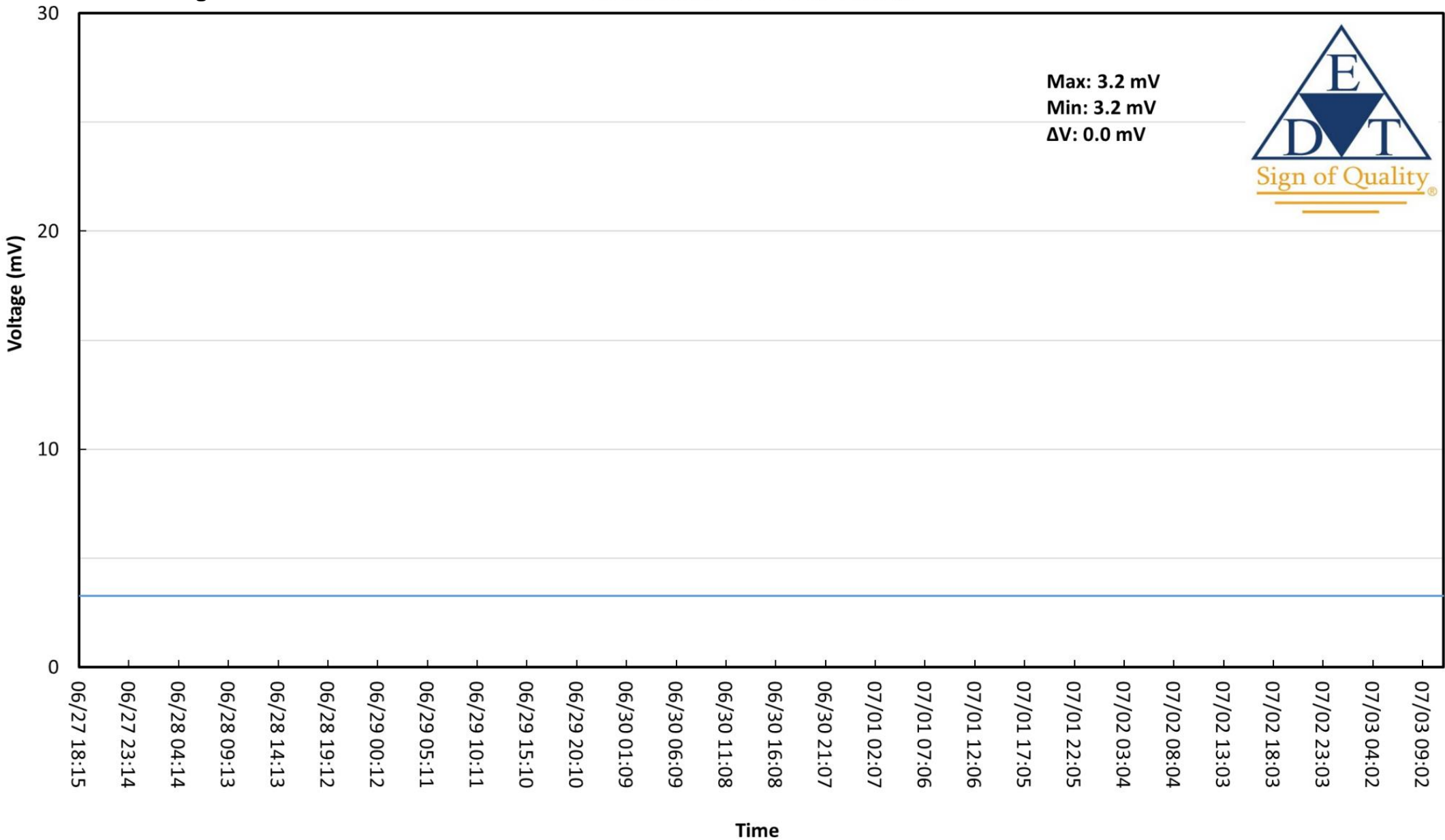
Location #1 - AC Stray Voltage





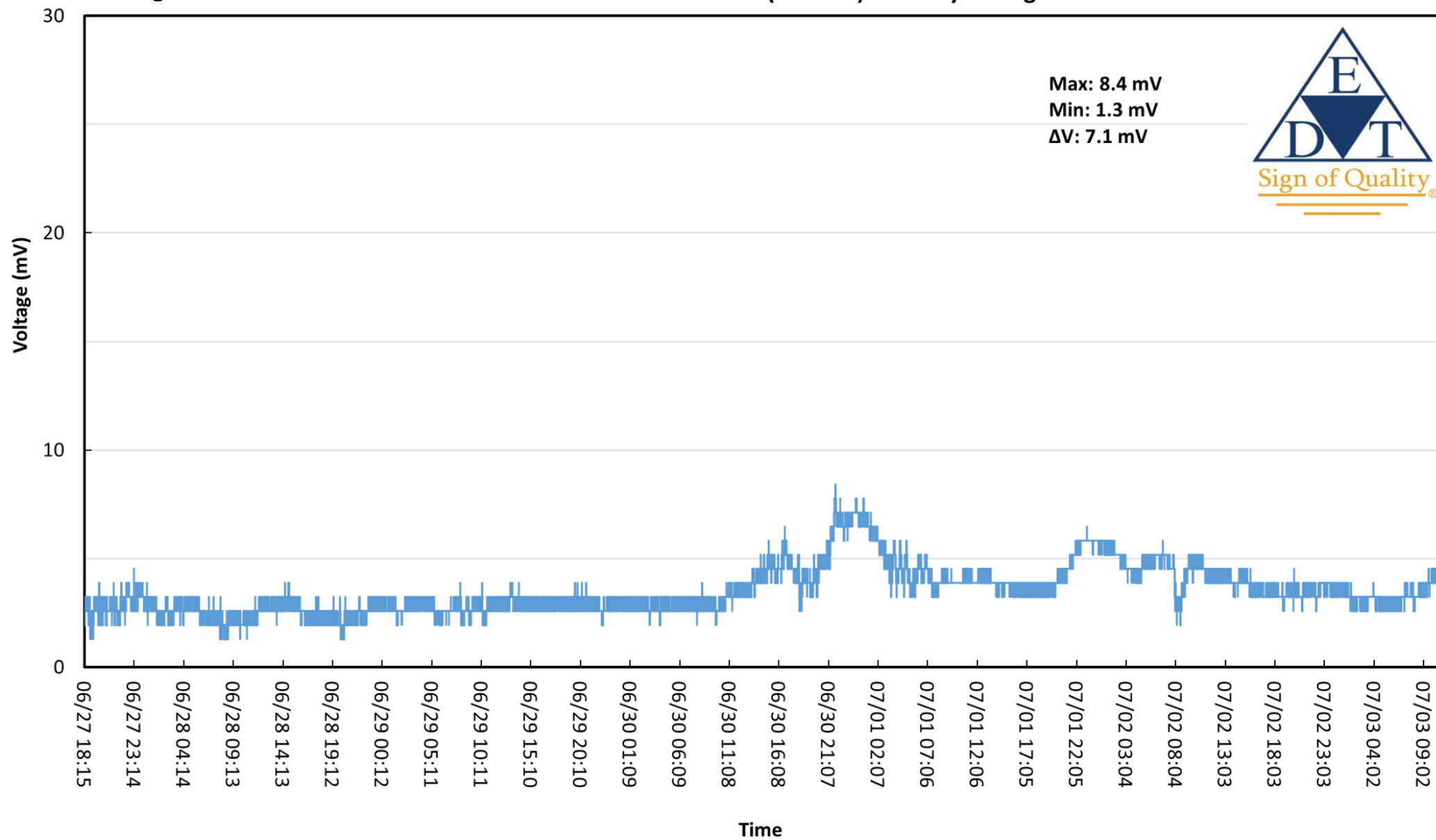
Long-term Test in Water: Around Dock

Location #2 - AC Stray Voltage



Long-term Test in Water: Around Dock

Location #3 - (Vertical) DC Stray Voltage



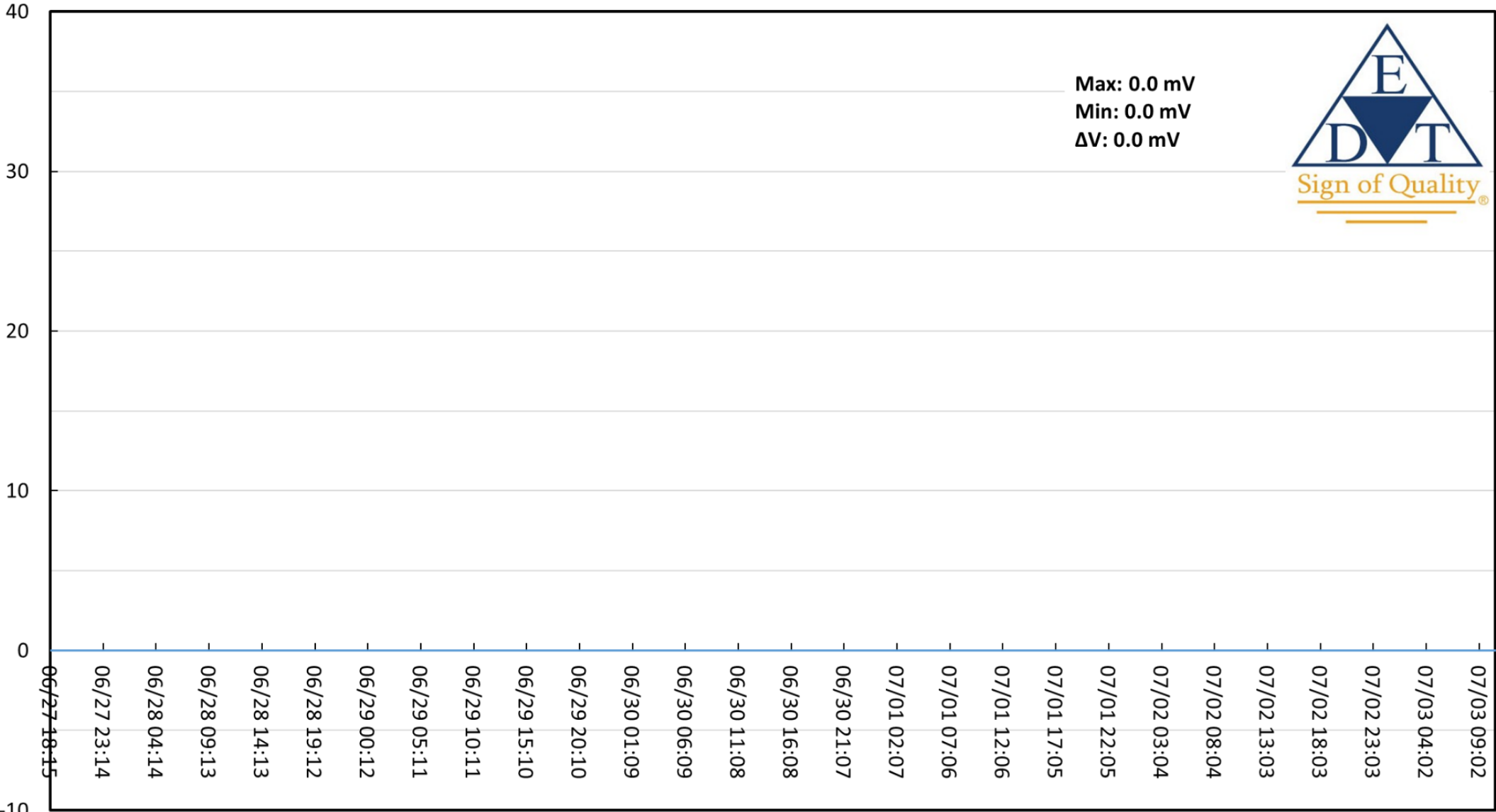
Long-term Test in Water: Around Dock

Location #3 - (Vertical) AC Stray Voltage

Max: 0.0 mV
Min: 0.0 mV
 ΔV : 0.0 mV

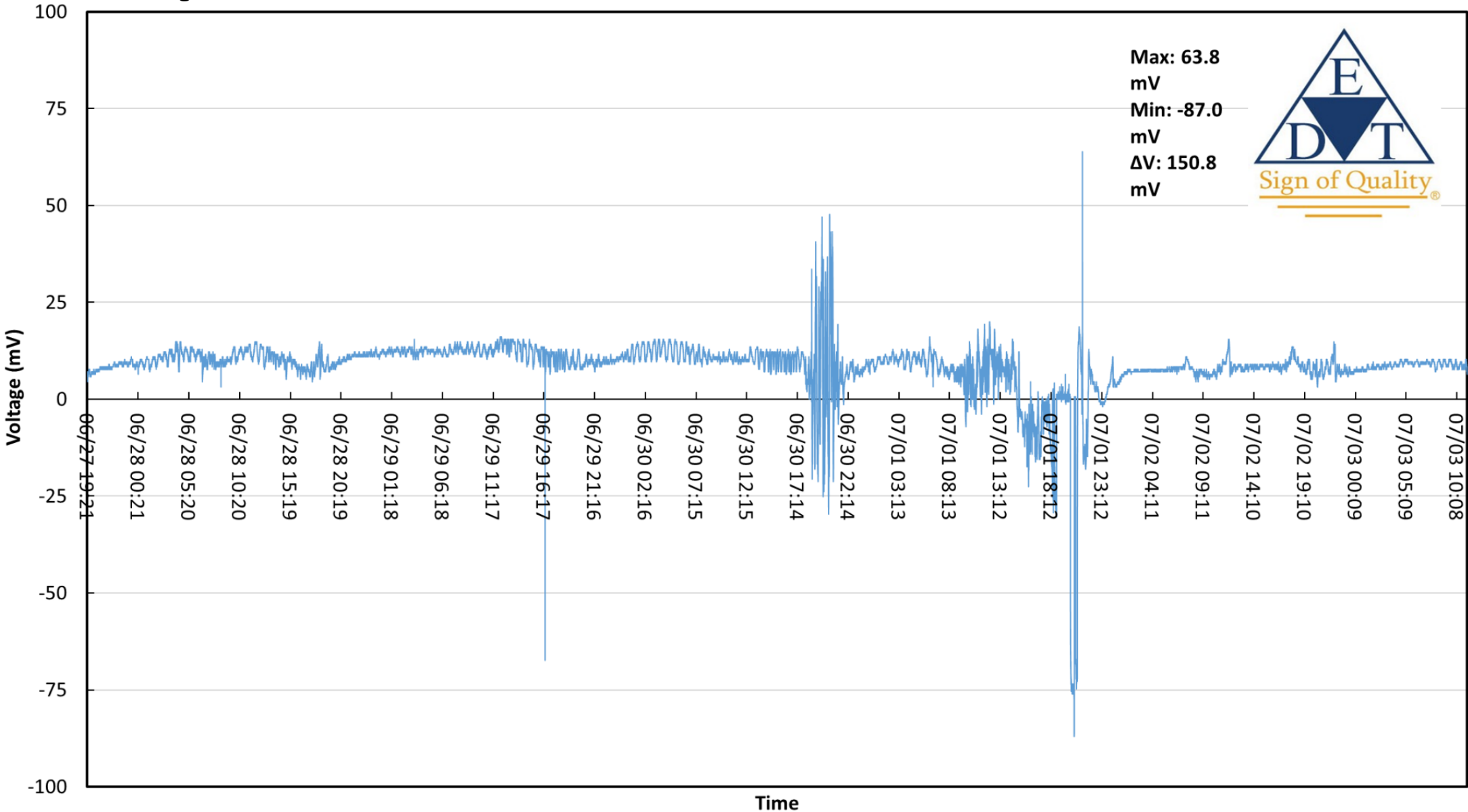


Voltage (mV)



Time

Long-term Test in Water: Around Dock Location #4 (Rickety Bridge) - DC Stray Current



Long-term Test in Water: Around Dock Location #4 (Rickety Bridge) - AC Stray Current

